

Using Animal-Borne Cameras to Quantify Prey Field, Habitat Characteristics and Foraging Success in a Marine Top Predator

John P.Y. Arnould

Deakin University

Burwood, VIC, 3125, Australia

phone: (+61 3) 9251-7465 fax: (+61 3) 9251-7048 email: john.arnould@deakin.edu.au

Award Number: N00014-10-1-0385

LONG-TERM GOALS

To understand the factors which influence population dynamics in marine mammals, and the potential risks anthropogenic activities pose, knowledge of their habitat use and the environmental factors determining foraging success is required. While over the last decade great advances have been made in this area for pelagic foraging species, such information is largely lacking for benthic foraging marine mammals. Therefore, the long term goals of this project are to determine in a model species (the Australian fur seal) the key ecological characteristics of their benthic foraging habitat, the profitability (prey captured *versus* effort) of various habitats and the spatial distribution of critical habitat. The techniques and principles developed in this project will be applicable for a variety of benthic foraging seal species world-wide and will contribute to our understanding of the role of top predators in shaping marine communities.

OBJECTIVES

The specific aims of the study are to:

- 1) quantify the prey fields encountered by adult female Australian fur seals in various habitats using video footage recorded on the seals;
- 2) determine seal movements at the fine-scale appropriate to prey encounters using GPS loggers and 3-axis accelerometers;
- 3) quantify net energy gain while foraging in different habitats; and
- 4) establish the habitat characteristics and individual factors that influence these parameters.

APPROACH

The aims of this study will be achieved through a conceptually simple, yet highly effective, methodological approach. Animal-borne video recording equipment will be combined with high resolution tracking to characterise and map the benthic habitats in which Australian fur seals forage and to determine the relative profitability of these habitats as measured by foraging success (prey consumption/energy expended).

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 2013		2. REPORT TYPE		3. DATES COVERED 00-00-2013 to 00-00-2013	
4. TITLE AND SUBTITLE Using Animal-Borne Cameras to Quantify Prey Field, Habitat Characteristics and Foraging Success in a Marine Top Predator				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Deakin University, Burwood, VIC, 3125, Australia,				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 6	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

The study will be conducted on Kanowna Island, northern Bass Strait, which hosts a large breeding colony with an annual production of *ca*3000 pups. Individual adult females suckling pups will be selected at random, captured and instrumented with a digital video recorder data logger (Cittercam[®] V5.7, National Geographic Society, Washington, USA) encased in a water-proof aluminium housing (5 cm diameter, 25 cm length). The device will be glued to the dorsal fur along the mid-line posterior to the scapula using quick-setting epoxy (Fig. 1). The Cittercam is designed to record high resolution, wide angle, video footage in low ambient daytime light levels encountered at depths of up to 100 m and on-board red LED beams provide sufficient light to record video at night. To enable complete foraging trips (6-10 days) to be sub-sampled, the Cittercam will record video data on a duty-cycle of 1 h on:3 h off. In addition to storing video footage, data from on-board sensors (depth \pm 0.5 m, 3-axis accelerometer \pm 0.06 G, compass \pm 1°) is recorded enabling accurate three-dimensional dive profiles to be reconstructed. From such profiles, linear distances travelled can be measured enabling the size of features along the sea floor to be calculated. As well as the Cittercam, a small VHF transmitter and a FastLoc GPS[®] data logger will also be attached to the animal to assist in relocating it at the colony for recapture and for recording at-sea movements, respectively. In total, all devices attached to the seals will represent <2% body mass and <1% cross-sectional surface area and, thus, negligible additional hydrodynamic drag (Wilson et al. 1986).



Fig.1: Adult female Australian fur seal (*Arctocephalus pusillus doriferus*) on Kanowna Island, northern Bass Strait, instrumented with a Cittercam[®] video data recorder, VHF transmitter and Fastloc GPS[®] logger.

To investigate potential individual factors influencing foraging behaviour, age and body size will be determined in the instrumented females. Once morphometric measurements have been collected and the animal has recovered from the anaesthesia, it will be released and left to forage for a single trip to sea before being recaptured and the devices removed by cutting the fur beneath them. Data from the loggers will be downloaded in the field onto portable computers and their batteries recharged so that they can be redeployed on additional animals.

In the laboratory, the at-sea movements of individuals instrumented with a Crittercam will be mapped using the data downloaded from the FastLoc GPS[®] logger concurrently deployed on them. The high accuracy of locations (± 10 m) and fast sampling interval (5 min) of these loggers, coupled with the 3-dimensional reconstruction of dive profiles using the accelerometer data, will enable foraging routes to be determined with very high resolution. The video recordings will then be analysed for the type, number and density (based on the length of foraging tracks) of prey encountered. The benthic habitats visited by seals will be categorised using the towed-video classification program developed for the Victorian Marine Habitat Mapping Program (Ierodiaconou et al. 2007). These analyses will enable statistical comparisons of prey fields, and capture rates, between various benthic habitat types.

WORK COMPLETED

Due to manufacturing delays, no cameras were available for deployment in 2013. Hence, analysis continued on the data acquired in the previous years of the project. Over the life of the project, a total of 40 adult female Australian fur seals were instrumented with a Crittercam[®] video data recorder, dive behaviour data logger, VHF transmitter and Fastloc GPS[®] logger. However, equipment failed or devices were lost at sea in 22 of these individuals resulting in incomplete information (e.g. GPS and dive behaviour records available but no video data; video data but no GPS or dive behaviour records). A total of 18 complete data set were obtained with a total of 41.2 h of video for 1067 foraging dives. These records were processed to provide geo-referenced locations of each video-recorded prey encounter, the prey type, the benthic habitat in which this occurred and the prey capture success. A total of 1772 prey encounters were observed, of which 1134 could be identified to Family level.

The degree of individual specialisation in prey consumption within the instrumented seals was investigated using the video data. This was compared to estimates of individual isotopic (δN and δC) niche-width within the same individuals using plasma and red cells obtained at the time of recapture. In addition, the δN and δC isotopic signatures of the whiskers of these individuals were analysed to determine whether patterns of specialisation observed in the videos reflected long-term trophic niche.

The distribution of prey types encountered was used in conjunction with the calculated distance covered along the sea floor by the seals to provide fisheries-independent estimates of their biomass. In addition, 26 individuals instrumented with video data loggers also had a three-axis accelerometer data logger deployed on the head. These devices are increasingly being used in free ranging pinnipeds to infer prey encounter/capture events from head movements but the technique has yet to be validated in free-ranging individuals. Due to equipment failure (video data loggers and accelerometers), only 4 complete data sets were obtained. Nonetheless, the results provide the first validation of the technique in free-ranging otariid seals and highlight the factors influencing its predictive accuracy.

Five manuscripts incorporating the results of the above analyses are currently under preparation for publication.

RESULTS

The bethos in the regions frequented by instrumented individuals was comprised overwhelmingly of sandy substrate populated by invertebrate communities. Due to low the clarity of the video data obtained during night-time foraging, a small proportion of substrate encountered could not be classified. Rocky reefs comprised <2% of substrate where seals foraged. Rocky reefs provide structural complexity which has been observed to influence associated fish and invertebrate

communities in near-shore marine environments. The low incidence of such habitats in the video records suggests their presence within the foraging range of Australian fur seals from the study colony is limited and that Bass Strait is largely featureless and uniform in habitat. Indeed, the only paratemeter in seafloor classification derived from the video data which displayed significant variability was invertebrate community density. These findings further highlight the potential beneficial impact of anthropogenic sea floor structures (e.g. pipelines, cables, wells etc.) in increasing prey diversity and abundance for top-order predators within Bass Strait. Indeed, some individuals may spend up to 30% of their foraging trip within 250 m of such structures.

A total of 1772 prey encounters were recorded across all individuals and dives, with a total of 1653 prey chases (93% of the prey encountered) and 1056 prey captures (64% of prey chased were captured). Of these captures, 947 (90%) were in the camera's field of view and 721 (76%) of these could be identified. These identifications were able to be sorted into 15 taxonomic orders: three orders of cephalopod, one order of crustacea, four orders of elasmobranch and seven orders of teleost fishes. Of these identifiable prey, the overwhelming majority 46% were Scorpaeniformes (Neobastids and Triglids). The next most common identifiable prey types were octopus (2.4%) Carangidae (*Trachurus* spp. and *Pseudocaranx* spp., 2.1%). At a higher taxonomic resolution, most prey events involved gurnards (*Lepidotrigla* spp., 18.7%) and unidentified benthic fishes (20.2%).

The capture rate of gurnards was higher (88.9%) than that of unidentified benthic fishes (59.8%) while the capture rate for cephalopods was 100%. Nonetheless, cephalopods (as well as stingrays) were uncommon prey. Decapods, small sharks and some teleost fish (e.g. *Hyporhamphus* spp, *Oplegnathus* spp.) contributed negligibly to the observed diet. Prey type was found to have a significant effect on capture success with octopuses, scorpaeniformes and leatherjackets being captured with greater success than carangids and unknown benthic fish.

Of the 1772 confirmed prey encounters, 1191 (67%) of items could be measured, where 869 (73.0%) of these were captures. Across all prey types that were measured, there was no significant difference in mean estimated size (mantle length for cephalopods and fork length for fish, excluding elasmobranchs). Most prey items captured for the common prey types were between 10-30 cm in estimated length (Fig. 2).

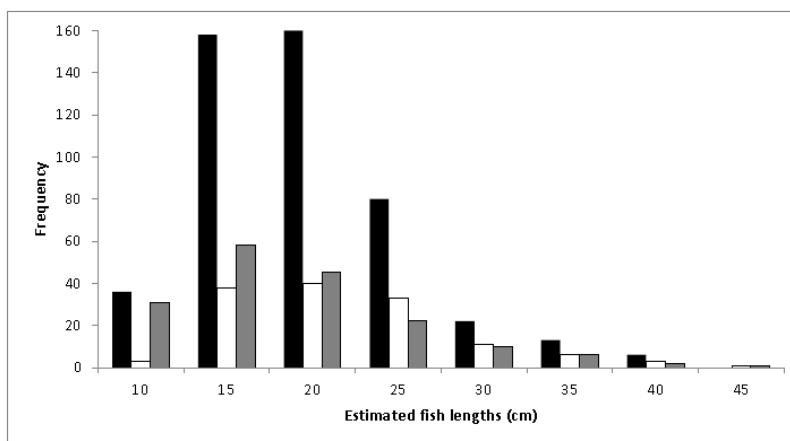


Fig. 2: The frequency distribution of the three dominant prey types detected in this study according to estimated FL (captured scorpaeniform fishes (excluding flatheads) – black; leatherjackets – white; unidentified benthic fish – grey)

Short-term individual specialisations occurred (proportion of the total niche width explained by within-individual variation $WIC/TNW=0.70$, mean pairwise overlap= 0.43) with up to 75% of items consumed by some individuals being of one prey type (e.g. gurnards, squids, stingrays). Stable isotope analyses of plasma revealed little inter-individual variation in $\delta^{13}C$ and $\delta^{15}N$ ratios (ranging from -19.2‰ and -17.8‰ and 15.7‰ and 16.9‰, respectively). However, $\delta^{15}N$ values were positively correlated with average prey size identified in the video data. Plasma values for both isotopes were correlated to red blood cell values indicating that individual differences in isotopic niches were consistent over 3-4 weeks. Furthermore, serially sampled whiskers from the same individuals provided an isotopic signature history for 4.2 ± 1.6 y. Mean isotopic signatures of whiskers were highly correlated with red cell values. Interestingly, differences between individuals were consistent along the length of the whiskers indicating that individual specialisations were persistent across seasons and years.

The spatial information on captures enabled estimates of biomass distribution to be calculated for 6 of the most common prey types. The results indicate localised hot spots of distribution for some of the prey types. Further analysis of the relationship between prey distribution and benthic habitat structure is currently ongoing.

The results from the head-mounted accelerometers showed that head movements during prey captures can be detected using acceleration in all 3 axis with weighted accuracies ranging from 34-38% (for all prey types were combined). The surge axis had a slightly higher weighted accuracy (38%) compared to the sway and heave (both 34%). These weighted accuracies were much lower than recorded on captive Steller sea lions (surge 68% heave 53%, Viviant et al. 2010). However, this previous study was conducted using only one type of dead prey provided to the individuals singularly and, hence, would have conducted less chasing and handling compared to a natural setting. Therefore, the results of the present study highlight the potential over-estimation of previous estimates of prey capture determined from head-mounted accelerometers.

IMPACT/APPLICATIONS

The overall aim of the proposed research is to determine the factors which influence spatial and temporal foraging success in an important marine predator. In particular, by employing new biologging and telemetry technology we will be able to quantify three particularly elusive aspects of marine mammal foraging ecology: the prey field, foraging success and foraging costs. The project focuses on the Australian fur seal where this information is vital for predicting how the most significant marine predator biomass in south-eastern Australia, and its impact on the marine ecosystem, will respond to environmental variability. The project, however, has broader international significance in that it will contribute to our understanding of the role of top predators in shaping marine communities, which is of particular importance given anticipated global climate change and the world-wide ever-increasing human exploitation of marine resources.

This study has additional global significance as the underlying principals determining foraging success will be applicable for a variety of benthic foraging seal species whose populations are currently under threat and where the impacts of bottom/demersal trawls by commercial fisheries on their prey field are unknown. Furthermore, an important and novel spin-off from this research will be improved mapping of sea-floor characteristics in many parts of the world, for a range of uses (e.g. environmental assessment, ecosystem monitoring), on a scale not feasible using conventional methods (i.e. hydrographic surveys and benthic trawl sampling).

RELATED PROJECTS

There are currently no projects directly related to the one being reported here.

REFERENCES

- Arnould JPY, Kirkwood R (2008) Habitat selection by female Australian fur seals (*Arctocephalus pusillus doriferus*). *Aquatic Conservation-Marine and Freshwater Ecosystems* 17:S53-S67
- Ierodiasconou D, Burq S, Reston M, Laurenson L (2007) Marine benthic habitat mapping using multibeam data, georeferenced video and image classification techniques in Victoria, Australia.
- Viviant, M., A. W. Trites, D. A. S. Rosen, P. Monestiez, and C. Guinet. 2010. Prey capture attempts can be detected in Steller sea lions and other marine predators using accelerometers. *Polar Biology* 33:713-719.
- Wilson RP, Grant WS, Duffy DC (1986) Recording devices on free-ranging marine animals: does measurement affect foraging performance? *Ecology* 67:1091-1093